

SELF-ORGANIZATION AND ARCHITECTURE
IN HUMAN AND ANIMAL SOCIETIES.

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A summary is presented here about the basic ideas of self-organization in human and animal systems essentially at the level of building behavior. Our goal is not to present a general law which governs living system from insects to man, but to study at different level of sociobiological and social systems, structuration which results from a multitude of decisions and interactions between the different components. The nature and complexity of these decisions and interactions are specific of each phenomena. A number of informations can be obtained with the help of mathematical formulation and specially with non-linear differential equations which describe the evolution of the system in time as a result of the multitude of interactions and decisions constitutive of the phenomena analysed.

The theory of self-organization developed in particular by the Brussels's School has shown in the case of chemistry and physics how a collection of microscopic processus under certain conditions concerning the non-linearity or feedback of the processus and the openness (exchange of energy and matter) of the system could lead by the amplification of random events (the fluctuations) to macroscopic structures called dissipative structures. The description of these structure is characterized by time and space scale much bigger than those of the underlying microscopic elementary processus. The basic ideas of self-organization applied to social or psychological field have given rise to the believe that the genesis of form, of collective activities, of social organization does not imply the agreement of the many participants concerned but can result from a multitude of divergent and partly random attitudes.

The analysis of animal's behavior has revealed a complex web of feed-back which governs the individual activities and the social organization. Take

for example, the building behavior of termites where each unit doesn't obey to a predetermined blue-print but react randomly to local stimuli which result from the activities of other animal or the spider which reacts during web's building to stimuli resulting from its behavior in the past.

The random events play a central fonction in problem of self-organization. In kybernetic and mechanical systems the work of the organs and the elements is supposed known and defined at the microscopic and macroscopic level whereas for the systems which are bringing forward, the behavior of variable is known in a probabilistic manner and their microscopic interaction do not automatically allow for macroscopic collective behavior. The latter will have to be obtained by aggregation.

This opposition is not absolute however, in the case of the ideal mechanical model the individual in the system, deterministically obey to predetermined blue print established at the level of the whole system. However, if we take the case of organization of an enterprise, we know very well that the flow chart of this enterprise is not sufficient to deduce the real role of each individual. It's an incomplete description, and the description shall never be able to take account of all events. But the attitude in front of the random events is absolutely different if amplification or damping of fluctuations is wanted. If the damping of fluctuations is wished, everything is made to stabilize the systems in a given state. The homeostatic system in biology characterizes this attitude, in which the feedback are constructed or have been selected to damp the fluctuations. In opposition to this ideas, the fluctuations have a central fonction of "imagination and exploration" Near particular point called bifurcation points, the system amplifies these random events and evolves toward a new structure. In other conditions, the fluctuations are damped, and the system is maintained in his initial state. The homeostatic systems correspond to this region. In the problem of architecture, we find homeostatic systems to damp the fluctuations occurring in the systems. One of the best example is the management of the temperature, humidity, and so on, in nest of social insects. Other systems as the construction of pillar in termites or combs in bees, exploit the instabilities of the bifurcation point.

The macroscopic law governing an entire system can not in general, be deduced directly from the knowledge of the observation of microscopic law. It's a reason why mathematical modelisation is necessary. It is already the case in relatively simple dynamic systems. We shall now examine some more concrete cases. Take for example, the case of synchronisation of activities inside a group. This synchronisation can be reached by two ways: reaction to an external order to an external stimulus or imitation of each other. A linear differential equation describe the external stimulus, a non-linear equation is used for imitation system. Suppose that two activities are in competition; X is the number of animals which present behavior x and Y the number with behavior y . The total number is N . For an external observator who looks the system at stationary state, the difference between the two ways doesn't appear. Now if he can compare groups of different dimensions the difference appears. The figure I shows this. The curve (a) present the fraction of X at the stationnary state in the case of external force, the fraction is independent of the number, only function of the external force. The curve (b) present the internally organized system. This curve represents the stationnary states of a differential equation which simulate a system in which members of the group adopt a behavior by imitation of each other. Take first the case where X and Y are equally favorised by external condition. Under critical number of the animals, the ratio (X/Y) is equal to 1. After this critical point, two new solutions appears in which the fraction of X is function of the number N . one poor in X , one rich in X . The point B is a bifurcation point. The random events result in choosing the branch poor or rich. Now when one form only is favorised by external conditions, the figure (b) is replaced by figure (c). We have represented the case which correspond to a very little avantage given to the form Y . So at low density (little group) the difference is very little, but when the density increase, we see that the form Y is largely advantaged, but fluctuations can still "drive" the system near the branch rich in X . This case (c) can result in amplifying very much little effect of environnements. The unity are not very sensible, but the group is very "efficace". Moreover, in the case with internal imitation the system conserves freedom that the linear system (a) has not.

This form of equations can be used for example to describe the building behavior of bees. In this phenomena the competition between different orientations of combs leads finally to the victory of one orientation. The large number of "decision" of bees and the interactions between bees and bees and wax-lead to a coherent structure.

The formation of highway in animal system, or footpath in village are this kind of process. The nature of the road can change, but the same basic ideas are maintained: competition between different sites, amplification by a large number of trips, constraint by geographical environment.

It's evident that in this kind of systems all the actors have not the same weight.

Only by local decision taken by termites which receive local information a coherent structure at the level of the colony with the formation of sub-structures with their specific function. We can say in a given species that the same central set of mechanisms is conserved. It is by the play of boundary conditions or by addition of some mechanism, that the diverse structures and their articulation can be developed.

In the case of the organisation of space by man, it is not only densities, but genesis of forms: landscapes, of villages, the organisation of homes which can be viewed as resulting of self-organized processes

The form of urban systems result from a multitude of interactions between the different players and the action of environment. The mathematical formulation of these processes can simulate the genesis of forms and test the relative importance of each elements and each mechanism. The simplest cases are the obtention of distribution of spatial densities and spatial segregation between the different components. A second step is the genesis of the form with these equations. An example is the distribution and relative position of houses in a village in function of the climatic, politic, and so on conditions. It is possible to develop relatively simple geographical games which can simulate and reproduce the structure observed. These game are systems of non-linear differential equations.

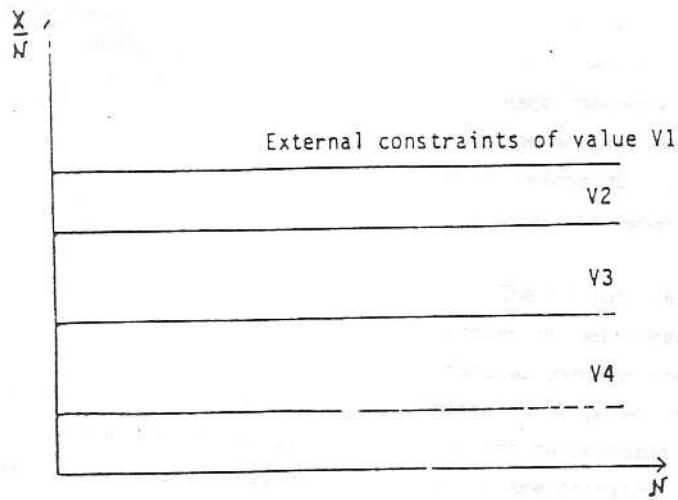


FIGURE I A

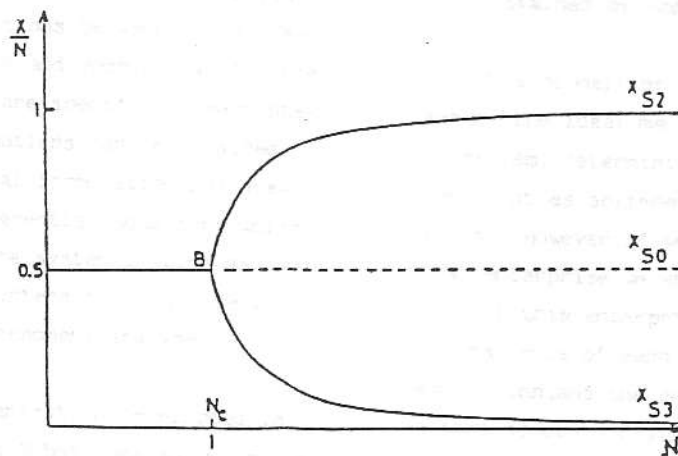


FIGURE I B

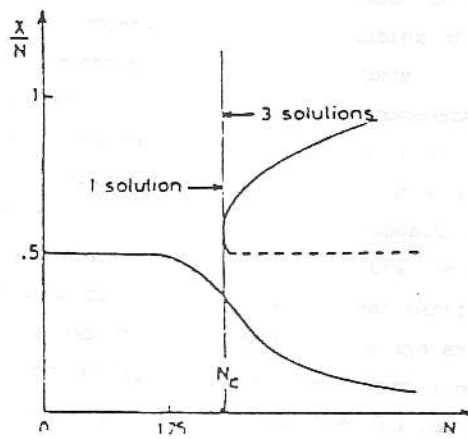


FIGURE I C